AD-A117 233 AIR FORCE HUMAN RESOURCES LAB BROOKS AFB TX F/G 5/2
FIGURES OF MERIT: USE AND INTERPRETATION IN EVALUATING PROGRAM --ETC(U)
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FIGURES OF MERIT: USE AND INTERPRETATION IN EVALUATING PROGRAM ALTERNATIVES

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June 1982

Final Technical Paper

AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS 78235

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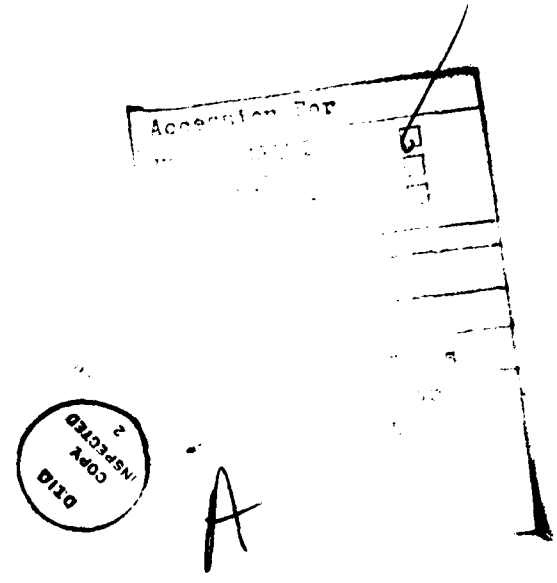

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SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFHRL-TP-82-14	2. GOVT ACCESSION NO. AD-A117233	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* FIGURES OF MERIT: USE AND INTERPRETATION IN EVALUATING PROGRAM ALTERNATIVES		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Thomas A. Boynton		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Analysis and Evaluation Office HQ Air Force Human Resources Laboratory Brooks Air Force Base, Texas 78235		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS HQ Air Force Human Resources Laboratory (AFSC) Brooks Air Force Base, Texas 78235		12. REPORT DATE June 1982 13. NUMBER OF PAGES 6
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

benefit cost ratio
figures of merit
net benefit
R&D leverage ratio
research and development

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This technical paper defines three figures of merit: the standard benefit cost ratio, net benefit, and the research and development (R&D) leverage ratio. It then discusses the mathematical relationships which exist among these figures of merit. Specific attention is given to the conditions under which the R&D leverage ratio is greater than the standard benefit cost ratio. Finally, a brief discussion is presented of subjective factors that must be considered in interpreting these figures of merit for the purpose of selecting from among a number of program alternatives.

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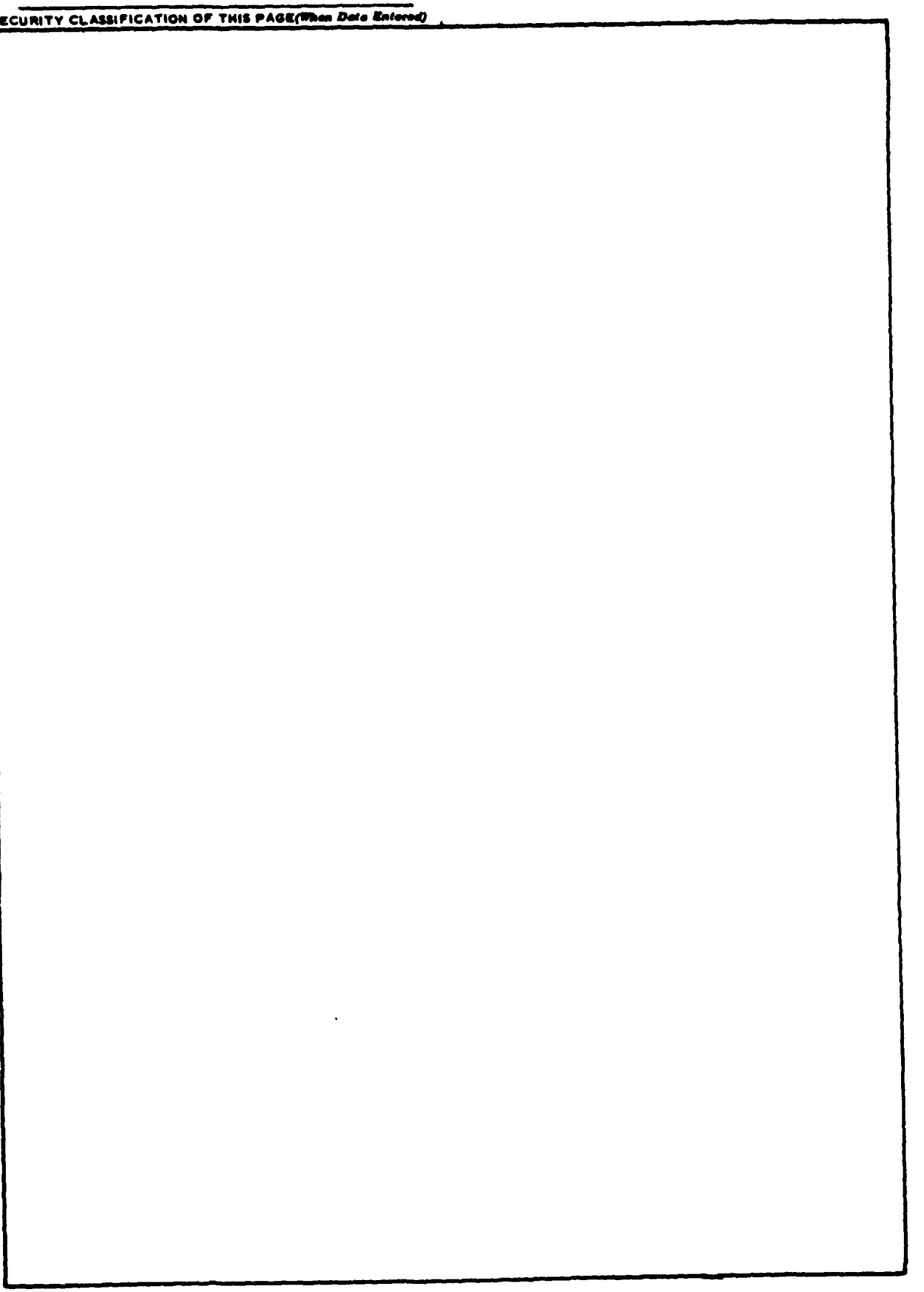

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FIGURES OF MERIT: USE AND INTERPRETATION IN EVALUATING PROGRAM ALTERNATIVES

The relative merits of research and development (R&D) program alternatives can be demonstrated using the following figures of merit.

1. *Standard Benefit Cost Ratio.* This is the ratio of total benefits to total costs, including R&D costs and implementation costs.

2. *Net Benefit.* This is the difference between total benefits and total costs.

3. *R&D Leverage Ratio.* This is the ratio of net benefits to R&D costs. The R&D leverage ratio will be greater than, or equal to, the benefit cost ratio as long as

$$b \geq I + 2R + \frac{R^2}{I}$$

where,

$b \equiv$ Total benefits

$R \equiv$ R&D costs

$I \equiv$ Implementation costs

$L \equiv$ R&D leverage ratio

$S \equiv$ *Standard benefit cost ratio*

$N \equiv$ Net benefit.

Otherwise, the leverage ratio will be less than the benefit cost ratio. This result is derived in Table 1.

Notice that if $b \geq I + 2R + \frac{R^2}{I}$

then, $b - (I + R) \geq R + \frac{R^2}{I}$

but, $b - (I + R)$ is simply the net benefit.

Thus, net benefit $N \geq R + \frac{R^2}{I}$, if and only if the R&D leverage ratio is $\geq$ benefit cost ratio.

Or, symbolically

$$N \geq R + \frac{R^2}{I} <=> L \geq S.$$

The R&D leverage ratio is a measure of how many net dollars of benefit can be made possible per dollar of R&D invested. Given R&D investment possibilities with identical standard benefit cost ratios, a reasonable policy might be to pick that alternative with the highest R&D leverage ratio. This method of selection would tend to result in projects with large impact per R&D dollar spent, in lieu of those with less significant impact. Of course, a high impact project could also be a bad investment if there is a large probability that the project will not be successful and if such an obvious lack of success is likely to negatively influence the organization's credibility, future funding, and continued usefulness. No one of these figures of merit should be used in a mechanical fashion to

make the decision as to which projects to fund. All must be carefully weighed by the decision maker, who at the same time must evaluate the political environment and other subjective factors.

Table 1. **Derivation of Necessary and Sufficient Conditions for Leverage Ratio to Exceed Standard Benefit-Cost Ratio**

Let $L \geq S$

but $L \equiv \frac{b-(I + R)}{R}$

and $S \equiv \frac{b}{I + R}$.

Thus, $\frac{b - (I + R)}{R} \geq \frac{b}{I + R}$.

If R is non-negative, then

$b-(I + R) \geq \frac{bR}{I + R}$.

If I + R is non-negative, then

$b(I + R) - (I + R)^2 \geq bR$,

$b(I + R) - bR \geq (I + R)^2$, and

$bI \geq I^2 + 2RI + R^2$.

If I is positive, then

$b \geq I + 2R + \frac{R^2}{I}$

which is the result previously used.